

## THE LAYOUT OF A DECODER AND THE METHOD THEREOF

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### BACKGROUND OF THE INVENTION

#### 5 Field of the Invention

This invention relates to a layout of a decoder and the method thereof, particularly to the layout of a decoder and the method with fewer masks and smaller circuit width.

#### Description of the Related Art

10 A LCD (Liquid Crystal Display) has a data driver and a scan driver. Colors or images on the display are transformed by the following mechanism. First, one of the scan lines, which are needed to be scanned, is determined by the scan driver. Then, all the pixels in one of the scan lines are updated by inputting data signals from the data driver. Take the color TFT LCD (thin film transistor LCD) for example, each pixel 15 includes three sub-pixels wherein the gray scale of each sub-pixel is controlled by a TFT (Thin Film Transistor). The three sub-pixels represent three colors of red, green and blue, respectively. Therefore, color of each pixel is controlled by three TFTs.

FIG. 1 shows the structure of driving circuit for a color TFT LCD 100. When the resolution of the color LCD is achieved by 1280 pixels×1024 lines, 3840 (1280×20 3) sub-pixels as well as TFTs for each scan line are required. Firstly, the data driver 106 receives digital image data D and transfers digital image data D to analog image

data by DAC 108 (Digital to Analog Converter, D/A). Then, the scan driver 104 selects scan line 114 (m) and the data of the sub-pixel on scan line(m) is updated through the data line 112 from the data driver 106.

In the LCD, each sub-pixel contains liquid crystal to decide transmittance thereof and the transmittance is controlled by the voltage applied to the liquid crystal. 5 If the voltage with the same polarity is constantly applied to the sub-pixel, liquid crystal will be easily damaged. The transmittance of each sub-pixel is related to the value of the applied voltage, not the polarity of the applied voltage. Therefore, the damage problem can be solved by polarity inversions.

10 FIG. 2 shows the circuit block diagram according to the DAC 108 in FIG. 1. DAC 108 comprises a plurality of P-type DAC unit 202, a plurality of N-type DAC unit 204, a plurality of buffer unit 206, switch units 210 and 212. The P-type DAC unit 202 includes a plurality of PMOS (P-type Metal-Oxide-Semiconductor), and the N-type DAC unit 204 includes a plurality of NMOS (N-type Metal-Oxide-Semiconductor). These P-type and N-type DAC units are arranged alternately, and they are used for outputting different voltage levels. As the digital 15 image data D of a scan line is inputted to the DAC unit 108, the digital data D(n) for each sub-pixel is selected by the switch unit 210, according to the dot inversion method or column inversion method, to input to the P-type DAC unit 202 or N-type DAC unit 204. If the digital data D(n) is inputted to the P-type DAC unit 202, the 20 digital data D(n) will be transferred to an analog signal V<sub>p</sub>. If the digital data D(n) is inputted to the N-type DAC unit 202, the digital data D(n) will be transferred to an analog signal V<sub>n</sub>. Thereafter, the analog signal V<sub>p</sub> and V<sub>n</sub> are inputted to the buffer unit 206 and the output signal V<sub>p'</sub> and V<sub>n'</sub> are produced, respectively. Next, the

switch unit 212 outputs these output signal  $V_p'$  and  $V_n'$  to one of the data lines according to the method used by switch unit 210. For the skilled in the art, it is well known that the analog signal  $V_p'$  and  $V_n'$  are the voltage with different polarity.

FIG. 3 shows the circuit diagram of N-type DAC unit 204 in FIG. 2. Herein, the 5 input of 3-bit is illustrated, and the digital data  $D(n)$  of 3-bit is provided. N-type DAC unit 204 comprises a resistor string  $R_s$ , an output line OUT and a decoder 302. The two ends of the resistor string  $R_s$  are respectively connected to the voltage  $V_c$  and  $V_d$ . The resistor string  $R_s$  is composed of  $R_0$  to  $R_6$  which are connected in series. Therefore, 8 kinds of different voltage level from  $V(0)$  to  $V(7)$  are provided.

10 Decoder 302 is composed of a plurality of transistor node 310 and a plurality of channel node 320 in the array arrangement. The gate of transistor in each column of the transistor node 310 are connected with each other, and thereby the decoder inputs of  $B(0)$  to  $B(5)$  are produced. The source/drain of transistor  $Q$  in each row of the transistor node 310 and the channel node 320 are connected in series, and thereby the 15 signal lines  $L(0)$  to  $L(7)$  are formed.

Please refer to FIG 4A and FIG. 4B at the same time. They show the circuit diagram of the transistor node 310 which contains a transistor  $Q$  and the circuit diagram of the channel node 320 which contains a connection line  $K$ , respectively. The decoder inputs  $B(0)$  to  $B(5)$  are used to receive the digital data  $D(n)$ . The digital 20 data  $D(n)$   $b_0'$ ,  $b_0$ ,  $b_1'$ ,  $b_1$ ,  $b_2'$ ,  $b_2$  are inputted to the decoder input  $B(5)$  to  $B(0)$ , respectively, wherein  $b_0$ ,  $b_1$ ,  $b_2$  are inverse of  $b_0'$ ,  $b_1'$ ,  $b_2'$ . The input ends of the signal lines  $L(0)$  to  $L(7)$  are coupled with the output ends of the resistor string  $R_s$ . All of the output ends of the signal lines  $L(0)$  to  $L(7)$  are commonly connected to the output line OUT. Output line OUT is used to output the analog signal while the digital

data are processed by the digital-to-analog conversion. The voltages V(0) to V(7) outputted from the resistor string Rs are inputted to the signal lines L(0) to L(7). The gates of the transistors on the signal lines L(i) are controlled by the decoder input B. When the transistors on the signal line L(i) are conducted, the output line OUT outputs voltage V(i). Meanwhile, only the transistors on the output line OUT are conducted, and only the input ends and the output ends on the signal line L(i) are conducted, wherein the  $0 \leq i \leq 7$ . For example, as the digital data D(n) is 000, --- all of b0', b1' and b2' are 1, only the transistors on the signal line L(0) are conducted. Therefore, the output line OUT outputs the analog signal Vn of voltage V(0).

FIG. 5 shows the layout of the decoder 302 in FIG. 3 according to the conventional method. The layout of each transistor node 310 for the decoder 302 comprises a gate 530, a source region 532 and a drain region 534, which correspond to a transistor area. Other than the gate 530, the source region 532 and the drain region 534, the layout of the channel node 320 further comprises a doped layer 526, which forms a short circuit between the source region 532 and the drain region 534 of the channel node 320, and make the transistor always conduct. The channel node 320 corresponds to a channel area. FIG. 6A to FIG. 6E show manufacturing method for the signal line L(0) in FIG. 5. The manufacturing process for the decoder 302 is as following. As shown in FIG. 6A, a substrate 624 is provided. Then, a doped layer 526 is formed in the channel area as shown in FIG. 6B. Next, the transistors are formed in whole transistor nodes 310 and whole channel nodes 320 of the decoder 302, which corresponds to FIG. 6C to FIG. 6E. In FIG. 6C, an oxide layer 628 is formed on the substrate 624. As shown in FIG. 6D, a plurality of gates 530 are formed on the oxide layer 628, and the source region 532 and drain region 534 are formed in the substrate 624 in FIG. 6E. These gates 530 are connected to the decoder input B and the

transistors are shorted because there is a doped layer 526 in the channel node 320. In this manner, the transistors are conducted and are not controlled by the decoder input B. Because the DAC 108(n) includes P-type DAC unit 202 and N-type DAC unit 204, it is necessary to form the P-type doped layer and N-type doped layer independently  
5 with two additional masks.

FIG. 7 shows the layout of the decoder 302 in FIG. 3 according to another conventional method. The decoder 302 is composed of a plurality of transistor nodes 310 and a plurality of channel nodes 320 in the array arrangement. The layout of each transistor node 310 for the decoder 302 comprises a gate 730, a source region 732 and 10 a drain region 734, which correspond to a transistor area. Other than the gate 730, the source region 732 and the drain region 734, the layout of the channel node 320 further comprises a short-circuited device 736, which causes a short circuit between the source region 732 to the drain region 734 for the channel node 320. The channel node 320 corresponds to a channel area. FIG. 8A to FIG. 8E show the manufacturing 15 method for the signal line L(0) in FIG. 7. The process for forming transistors in whole transistor nodes and channel nodes of the decoder 302 is as follows. As shown in FIG. 8A, a substrate 824 is provided. Then, an oxide layer 828 is formed on the substrate 824, as shown in FIG. 8B. Next, a plurality of gates 730 is formed on the oxide layer 828 as shown in FIG. 8C. In FIG. 8D, the source region 732 and drain region 734 are 20 formed in the substrate 824 and the layout of the transistor is finished. Referring to FIG. 8E, an insulating layer 838 is formed on the substrate 824 and a short-circuited device 736 is defined in the channel area by forming a metal layer on the insulating layer 838. The first contact 740 and the second contact 742 of the short-circuited device 736 penetrate through the insulating layer 838 and connect to the source region 25 732 and drain region 734, respectively. Therefore, a short circuit is formed between

the source 732 and drain 734. Moreover, the gate 730 is connected to the decoder input B and the transistor is always conducted. Since the short-circuited device 736 connects to the source 732 and drain 734 of the transistor in the channel area, the transistor is not controlled by any one of the decoder input B.

5        Although such conventional method doesn't have the step of forming a doped layer with additional masks---- the P-type and N-type, the circuit width of the DAC unit is increased because the connection between the short-circuited device 736 and the source 732, drain 734 is completed by the contacts. In addition, if 10 data drivers are used in a panel, there are 384 DAC units in the data driver, which make the entire 10 circuit width of the DAC units large. For the DAC unit with 6-bit, the later conventional method is difficult but can be implement. And this data driver will become too long to use if the DAC unit is of 8 bits.

## SUMMARY OF THE INVENTION

15      The object of the present invention is to provide the layout of decoder and the method thereof wherein the decoder has smaller circuit width and is manufactured with reduced masks.

According to the purpose of the present invention, a decoder structure with  $m \times n$  nodes is provided, and the nodes comprises a plurality of transistor nodes and a 20 plurality of channel nodes. The transistor node  $N(i_1, j_1)$  corresponds to a transistor area  $A(i_1, j_1)$ , and the channel node  $N(i_2, j_2)$  corresponds to a channel area  $A(i_2, j_2)$ , wherein the  $i_1, i_2, j_1$  and  $j_2$  satisfy the relations of  $1 \leq i_1, i_2 \leq m, 1 \leq j_1, j_2 \leq n, i_1 \neq i_2$ ,

j<sub>1</sub> ≠ j<sub>2</sub>. The decoder structure comprises a substrate, a first source/drain region, a second source/drain region, a channel, a first insulating layer, a gate, a second insulating layer and a metal layer. The first source/drain region and the second source/drain region are positioned on the substrate in the transistor area A(i<sub>1</sub>, j<sub>1</sub>). The  
5 channel on the channel area A(i<sub>2</sub>, j<sub>2</sub>) is disposed within the substrate. The first insulating layer covers the first source/drain region, the second source/drain region and the channel. The gate is disposed on the first insulating layer and between the first source/drain region and the second source/drain region. The second insulating layer covers the gate. The metal layer is positioned over the gate and electrically connects  
10 the gates in the same column to form a decoder input.

While the transistor node N(i<sub>1</sub>, j<sub>1</sub>) and the channel node N(i<sub>2</sub>, j<sub>2</sub>) are on the same row and connected to each other, the first source/drain region and the second source/drain region of said transistor area A(i<sub>1</sub>, j<sub>1</sub>) are connected to the channel of the channel area A(i<sub>2</sub>, j<sub>2</sub>).

15 While the transistor node N(i<sub>1</sub>, j<sub>1</sub>) is next to the transistor node N(i<sub>3</sub>, j<sub>3</sub>) on the same row, the first source/drain or the second source/drain of the transistor node N(i<sub>1</sub>, j<sub>1</sub>) is connected to the first source/drain or the second source/drain of the transistor node N(i<sub>3</sub>, j<sub>3</sub>).

20 While the channel node N(i<sub>2</sub>, j<sub>2</sub>) is in the proximity of the channel node N(i<sub>4</sub>, j<sub>4</sub>) on the same row, the channel of the channel node N(i<sub>2</sub>, j<sub>2</sub>) is connected with the channel of the channel node N(i<sub>4</sub>, j<sub>4</sub>).

One end of the nodes on the same column is for receiving a signal and the other end of the nodes connects to the data line, which is used to output the signal

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selectively. The metal layer is used to electrically connect the gates of the transistor nodes on the same column, and thereby forming Y decoder inputs to receive a digital signal data.

According to another purpose of the invention, a method for manufacturing the structure of the decoder is provided. The decoder comprises m signal lines, n decoder inputs, p transistor nodes and  $(m \times n - p)$  channel nodes, wherein p is an integer smaller than  $m \times n$ . First, a substrate is provided and an insulating layer is formed on the substrate. Then, p gates are formed on the transistor area. Next, p first sources/drain regions and p second sources/drain regions are formed on the transistor area, and, meanwhile,  $(m \times n - p)$  channels are formed on the channel area to complete m signal lines. Afterwards, a second insulating layer is formed, and the decoder input is formed by depositing selectively patterning a metal layer. The decoder inputs electrically connect to the gates with a plurality of contacts.

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## BRIEF DESCRIPTION OF THE DRAWINGS

The above objects and other advantages of the present invention will become more apparently by describing in detail the preferred embodiment of the present invention with reference to the attached drawings in which:

FIG. 1 shows a driving circuit for the color TFT LCD.

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FIG. 2 shows a block diagram of the driving circuit of a DAC in FIG. 1.

FIG. 3 shows a conventional circuit diagram of an N-type DAC unit in FIG. 2.

FIG 4A shows a circuit diagram of the transistor node.

FIG. 4B shows a circuit diagram of the channel node.

FIG. 5 shows a conventional layout of the decoder in FIG. 3.

FIG. 6A to FIG. 6E show cross-sectional view illustrating manufacture of the  
5 signal line L(0) in FIG. 5.

FIG. 7 shows another conventional layout of the decoder in FIG. 3.

FIG. 8A to FIG. 8E show cross-sectional view illustrating manufacture of the  
signal line L(0) in FIG. 7.

FIG. 9A shows the layout of the decoder in FIG. 3 according to a preferred  
10 embodiment of the present invention.

FIG. 9B shows the sectional view of the signal line L(0) in FIG. 9A.

FIG. 10A to FIG. 10E show cross-sectional view illustrating manufacture of the  
signal line L(0) of the decoder according to the preferred embodiment of the present  
invention.

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#### **DESCRIPTION OF THE PREFERRED EMBODIMENTS**

As shown in FIG. 9A, it illustrates a layout of the decoder 302 in FIG. 3  
according to a preferred embodiment in the present invention. The decoder 302

comprises 8\*6 nodes, and each node contains a plurality of transistor nodes 310 and a plurality of channel nodes 320, which, respectively, correspond to a transistor area and a channel area. The layout of each transistor node 310 comprises a gate, a source and a drain. The channel node 320 contains a channel. The gates on the same column  
5 of the transistor node are connected to each other so that decoder input B(0) to B(5) are formed. The transistor nodes and the channel nodes on each row are connected in series and thus the signal line L(0) to L(7) are formed.

FIG. 9B shows cross-sectional view of the signal line L(0) in FIG. 9A. The signal line L(0) comprises a substrate 924, a first source/drain region 932, a second 10 source/drain region 934, a channel region 936, a first insulating layer 928, a gate 930, a second insulating layer 938 and a metal layer 940. The first source/drain region 932 and the second source/drain region 934 are positioned within the substrate 924 in the transistor area A(0,1), A(0,3) and A(0,5). The channel 936 is disposed within the substrate 924 in the channel area of A(0,0), A(0,2) and A(0,4). The first source/drain 15 region 932, the second source/drain region 934 and the channel 936 are covered with the first insulating layer 928. The gate 930 formed on the first insulating layer 928 is disposed between the first source/drain region 932 and the second source/drain region 934. Furthermore, the gate 930 is covered with the second insulating layer 938, and the metal layer 940 formed on the second insulating layer 938 is electrically 20 connected to the gate 930.

The transistor node N(0,1) and the channel node N(0,0) on the same row are connected to each other in the proximity. The first source/drain 932 region is connected to the channel of the channel area A(0,0). The gates 930 of the transistor node on the same column are electrically connected to each other by the metal layer

940, and, accordingly, six decoder inputs are formed to receive the data signal D(n).

The transistor node 310 in the present invention is manufactured using conventional processes. The gate 930, the first source/drain region 932 and the second source/drain region 934 are sequentially formed. The fabrication of the channel node 5 320 is completed by the step of forming a channel. Without additional mask, the channels 936, the first source/drain region 932 and the second source/drain region 934 are formed simultaneously. FIG. 10A to FIG. 10E are cross-sectional view of manufacturing the signal line L(0) of the decoder 302 according to the preferred embodiment of the invention. In FIG. 10A, a substrate 924 is provided. Then, an 10 insulating layer 928 is formed on the substrate 924, and a plurality of gates 930 are formed in the transistor area A(0,1), A(0,3) and A(0,5), as shown in FIG. 10B and 10C. Referring to FIG. 10D, the channels 936 are formed within the substrate 924 directly in the A(0,0), A(0,2) and A(0,4) because no gate covers the channel area A(0,0), A(0,2) and A(0,4). Therefore, the signal line L(0) to L(7) are formed. 15 Meanwhile, the channels of the channel area A(0,0), A(0,2) and A(0,4) are electrically connected with the first source/drain region 932 or the second source/drain region 934 of the transistor area A(0,1), A(0,3) and A(0,5), respectively. Then, referring to FIG. 10E, a metal layer 940 is formed over the substrate 924 and is patterned to form the 20 decoder input B(0) to B(5), which are electrically connected with the gates 930 on the same column by a plurality of contacts 942.

Since the channel of the channel area and the source/drain region of the transistor area are formed simultaneously in the invention, it is not necessary to add the P-type and N-type channel as the conventional method. Hereby, two masks are reduced in the invention. Moreover, the circuit width of the present invention is

decreased without the formation of the short by metal layer. Therefore, the decoder layout of the smaller circuit width is accomplished without additional mask.

Once given the above disclosure, many other features, modifications, and improvement will become apparent to the skilled artisan. Such other features, 5 modifications, and improvements are, therefore, considered to be a part of this invention, the scope of which is to be determined by the following claims.

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